80/253/NP

NEW WORK ITEM PROPOSAL

Proposer	Date of proposal
Secretary TC 80	1999-12-16
TC/SC: 80	Secretariat: UK
Date of circulation: 1999-12-24	Closing date for voting: 2000-03-31

A proposal for a new work item within the scope of an existing technical committee or subcommittee shall be submitted to the Central Office. The proposal will be circulated to the P-members of the technical committee or subcommittee for voting, and to the O-members for information. The proposer may be a National Committee of the IEC, the secretariat itself, another technical committee or subcommittee, an organization in liaison, the Committee of Action or one of the advisory committees, or the General Secretary. Guidelines for proposing and justifying a new work item are given in ISO/IEC Directives, Part 1, Annex Q (see extract overleaf). **This form is not to be used for amendments or revisions to existing publications.**

The proposal (to be completed by the proposer)

Title of proposal

IEC 61162 – Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 3: Serial data instrument network

☒ Standard ☐ Technical Report

Scope (as defined in ISO/IEC Directives, Part 3, 6.2.1)

The minimum implementation of a serial-data communications network to interconnect marine electronic equipment on board vessels. It supports bi-directional data communication between multi-talker and/or multi-listeners at a speed of 250 kbit/s.

Purpose and justification, including the market relevance and relationship to Safety (Guide 104), EMC (Guide 107), Environmental aspects (Guide 109) and Quality assurance (Guide 102) . (attach a separate page as annex, if necessary)

Target date	for first CD 2000 - 05 - 01.	for IS .2001 - 10 - 01
Estimated number of meetings 3	Frequency of meetings 3 per year	Date and place of first meeting: continuing
Proposed working methods	☒ E-mail	☒ ftp

Relevant documents to be considered

NMEA 2000

Relationship of project to activities of other international bodies

The 61162 series is being developed at the request of the International Maritime Organization (IMO) as an essential contribution to safety of life at sea.

Liaison organizations	**Need for coordination within ISO or IEC**
CIRM, IMO, NMEA, RTCM	None

Preparatory work

Check one of the two following boxes

☐ A draft is attached for vote and comment ☒ An outline is attached

We nominate a project leader as follows in accordance with ISO/IEC Directives, Part 1, 2.3.4 (name, address, fax and e-mail): M P Fox. 13 Croft Road, Wokingham, Berks. RG11 3HX. United Kingdom. Facsimile: 00 44 118 9784 796. e-mail: mpfox@btinternet.com

Concerns known patented items (see ISO/IEC Directives, Part 2)	**Name and/or signature of the proposer**
☐ yes ☒ no	P F C GRIFFITHS
If yes, provide full information as an annex	

Comments and recommendations from the TC/SC officers

Comments with respect to the proposal in general, and recommendations thereon		
1) Work allocation		
☐ Project team	☐ New working group	☒ Existing working group no:
2) Draft suitable for direct submission as		
☐ CD	☐ CDV	
3) General quality of the draft (conformance with ISO/IEC Directives, Part 3)		
☒ Little redrafting needed	☐ Substantial redrafting needed	☐ no draft (outline only)
4) Relationship with other activities In IEC Part of the IEC 61162 Series In other organizations NMEA		
Other remarks		

This new work is being proposed by the Secretary IEC TC 80 in order to conform strictly with the IEC Directives.

When work first started on the IEC 61162 series, four parts were envisaged namely:

Part 1 – Single talker and multiple listeners. This has been published and is currently undergoing revision.

Part 2 – Single talker and multiple listeners – high speed transmission. This has been published and will require revision in the future to maintain alignment with the revised Part 1.

Part 3 – Serial data instrument network. Specific IEC work is about to commence.

Part 4 – Large ship network. A CD has been circulated for comment. A CDV is being prepared. This is a very large and complex standard – some 400 pages. It has been agreed with IEC Central Office to issue it as 61162 – 4 – 101, 102, 201, 202 etc,.

There has been very close co-operation with the National Marine Electronics Association of the USA (NMEA) from the start of this work. Much of the content of Part 1 is derived from NMEA publications, and there has been a declared aim between IEC and NMEA to maintain alignment between their respective publications as much as possible.

With regard to Part 3, IEC TC 80 Working Group 6 which is developing the 61162 series, has agreed with NMEA to base it on the NMEA 2000 publication. NMEA 2000 is currently being given final evaluation. On the assumption that this is successful, NMEA will publish it during 2000. This will allow TC 80 WG 6 to use it to create Part 3 of 61162. It is expected that only minimal change will be required.
A copy of the current version of NMEA 2000 is attached. It will be observed that this is a fully mature draft and will require little change to turn it into a draft IEC standard. It could therefore be expected that this will be circulated to IEC members within the next 6 months as a CDV.

To conform with current IEC Directives this new proposal is being circulated for approval.

Current members of the IEC TC 80 Working Group 6 are Denmark, Germany, Italy, Japan, Norway, Russia, Sweden, UK and USA, together with CIRM, ISO TC8/SC5, NMEA and RTCM. I t would be expected that these would continue as members of the Working Group.

In their replies members are invited not only to support the proposal, but also to confirm their membership of the current Working Group. New members are welcome

It should also be noted that replies should be sent to the new Secretary of IEC TC 80 (from 2000 – 01 – 01):

Mr M Rambaut
Southbank House
Black Prince Road
LONDON. SE1 7SJ
United Kingdom.

Telephone: 00 44 (0) 171 587 1245
Facsimile: 00 44 (0) 171 587 1436

e-mail: cirm@btinternet.com

The members of IEC TC 80 are strongly encouraged to support this proposal

Elements to be clarified when proposing a new work item

Title

Indicate the subject matter of the proposed new standard.

Indicate whether it is intended to prepare a standard, a technical report or an amendment to an existing standard.

Scope

Give a clear indication of the coverage of the proposed new work item and, if necessary for clarity, exclusions.

Indicate whether the subject proposed relates to one or more of the fields of safety, EMC, the environment or quality assurance.

Purpose and justification

Give details based on a critical study of the following elements wherever practicable.

a) The specific aims and reason for the standardization activity, with particular emphasis on the aspects of standardization to be covered, the problems it is expected to solve or the difficulties it is intended to overcome.

b) The main interests that might benefit from or be affected by the activity, such as industry, consumers, trade, governments, distributors.

c) Feasibility of the activity: Are there factors that could hinder the successful establishment or general application of the standard?

d) Timeliness of the standard to be produced: Is the technology reasonably stabilized? If not, how much time is likely to be available before advances in technology may render the proposed standard outdated? Is the proposed standard required as a basis for the future development of the technology in question?

e) Urgency of the activity, considering the needs of the market (industry, consumers, trade, governments etc.) as well as other fields or organizations. Indicate target date and, when a series of standards is proposed, suggest priorities.

f) The benefits to be gained by the implementation of the proposed standard; alternatively, the loss or disadvantage(s) if no standard is established within a reasonable time. Data such as product volume of value of trade should be included and quantified.

g) If the standardization activity is, or is likely to be, the subject of regulations or to require the harmonization of existing regulations, this should be indicated.

If a series of new work items is proposed, the purpose and justification of which is common, a common proposal may be drafted including all elements to be clarified and enumerating the titles and scopes of each individual item.

Relevant documents

List any known relevant documents (such as standards and regulations), regardless of their source. When the proposer considers that an existing well-established document may be acceptable as a standard (with or without amendments), indicate this with appropriate justification and attach a copy to the proposal.

Cooperation and liaison

List relevant organizations or bodies with which cooperation and liaison should exist.

Preparatory work

Indicate the name of the project leader nominated by the proposer.

Future IEC 61162-3

Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 3 – Serial data networking of marine electronic devices

CONTENTS

1 General

1.1 Introduction

The need exists for standardized data communications between various electronic devices onboard ships and smaller recreational and commercial vessels. Requirements cover the broad spectrum of simple data buses that distribute data, to full scale office/factory automation local-area-networks (LANs). The single existing standard, NMEA 0183 (IEC 61162-1), provides serial-data distribution from a single transmitter to multiple receivers. Currently several companies are marketing various proprietary multi-transmitter network systems, often with NMEA 0183 input or output ports, but there is no compatibility between systems.

The International Electrotechnical Commission (IEC) has the responsibility to provide standards to be referenced by the International Maritime Organization (IMO) for equipment required on board ships under the SOLAS convention. For distribution of digital data to equipment onboard ships IEC has adopted NMEA 0183 as the basis for IEC 61162-1, a single-transmitter/multi-receiver data bus. A higher speed variant of NMEA 0183/IEC 61162-1 is described by IEC 61162-2. IEC has further identified the need for both moderate capacity instrument networks and high capacity LANs. IEC Technical Committee 80, Working Group 6 (Digital Interfaces) is developing a standard for a high capacity, high security shipboard LAN (IEC 61162-4).

This IEC standard IEC 61162-3, has adopted NMEA 2000 as its basis. It describes a low cost, moderate capacity, bi-directional multi-transmitter/multi-receiver instrument network to interconnect marine electronic devices.

1.2 Scope

This standard contains the requirements for the minimum implementation of a serial-data communications network to interconnect marine electronic equipment onboard vessels. Equipment designed to this standard will have the ability to share data, including commands and status, with other compatible equipment over a single signaling channel.

Data messages are transmitted as a series of data frames, each with robust error checking, confirmed frame delivery and guaranteed latency times. As the actual data content of a data frame is at best 50% of the transmitted bits, this standard is primarily intended to support relatively brief data messages which may be periodic, transmitted as needed, or on-demand by use of query commands. Typical data includes discrete parameters such as position latitude and longitude, GPS status values, steering commands to autopilots, finite parameter lists such as waypoints, and moderately sized blocks of data such as electronic chart database updates. This standard is not necessarily intended to support high-bandwidth applications such as radar, electronic chart or other video data, or other intensive database or file transfer applications.

This standard defines all of the pertinent layers of the International Standards Organization Open Systems Interconnect (ISO/OSI) model, from the Application Layer to the Physical Layer, necessary to implement the required network functionality.

The components of this network are:

- Physical Layer. Defined by this standard in Section 2.0.
- Data Link Layer. Defined by ISO 11783-3 with additional requirements specified in Section 3.0.
- Network Layer. Defined by this standard in Section 4.0.
- Network Management. Defined by ISO 11783-5 with additional requirements specified in Section 8.0.
- Application Layer. Defined by this standard in Appendix A.

The scope and configuration of the network is illustrated Figure 1-1, see also section 1.4 Definitions.

This standard defines data formats, network protocol, and the minimum physical layer necessary for devices to interface. Single point-of-failure conditions could exist that are capable of disrupting network operation. For critical applications it may be necessary to employ fail-safe designs (e.g., dual networks, redundant cables and network interface circuits) to reduce the possibility of network failure. These methods are beyond the scope of this standard.

1.3 Network Characteristics

1. Network architecture:
   - Single channel
   - Bus (parallel) wiring configuration
   - Linear network with end terminations and multiple drops for individual nodes
   - Network access: Carrier Sense/Multiple Access/Collision Arbitration
2. Multi-master network operation, self-configuring. Special network tools, desirable for diagnostic purposes, are not necessary for operation.
3. Physical network size:
   - Up to 50 physical node connections
   - Signaling rate - backbone length: 250kbits/second – 200 meters. The maximum length of the network is controlled by the CAN requirement that all nodes on the network sample the same bit at the same time, the actual maximum length will be determined by the time delays on the network cable and in the interface circuits. Future versions of this standard may support additional signaling rates:
     - ➢ 1,000 kbits/second - 25 meters
     - ➢ 500 kbits/second - 75 meters
     - ➢ 125 kbits/second - 500 meters
     - ➢ 62.5 kbits/second - 1100 meters
   - Drop length, maximum: 6 meters
   - Node separation, minimum: 0

4. Functional network size:
   - 254 network addresses, maximum
5. Media Access Control hardware:
   - Controller Area Network (CAN), Version 2.0B Extended Format
6. Connectors, cables, terminations:
   - Specified in Section 2.0
7. Dedicated network power
   - Specified in Section 2.0
   - Network interface operating range: 9 to 16 Volt DC
8. Network fault operation is defined in Table 1-1:

Table 1-1 Fault Conditions

Condition		Network Operation
1	A device is disconnected from the network	Possible temporary network interruption and/or re-initialization of network connected devices.
2	A device loses external power	No impact on network physical layer
3	A device loses external ground	No impact on network physical layer
4	A device loses network power	No impact on network physical layer
5	A device loses network ground	No impact on network physical layer

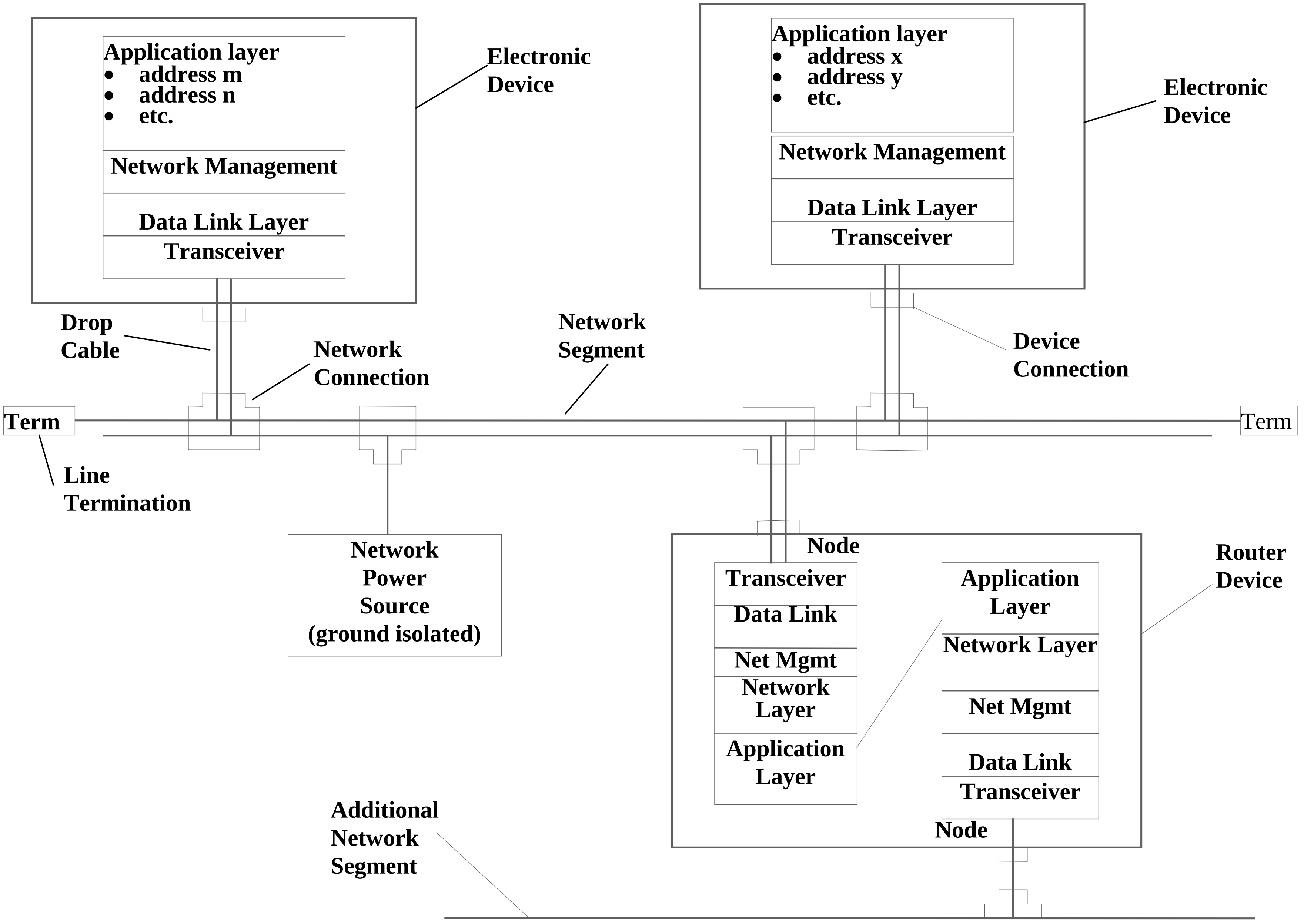
Application layer
• address m
• address n
• etc.
Network Management
Data Link Layer
Transceiver
Electronic Device
Application layer
• address x
• address y
• etc.
Network Management
Data Link Layer
Transceiver
Electronic Device
Drop Cable
Network Connection
Network Segment
Device Connection
Term
Term
Line Termination
Network Power Source (ground isolated)
Node
Transceiver
Data Link
Net Mgmt
Network Layer
Application Layer
Application Layer
Network Layer
Net Mgmt
Data Link
Transceiver
Node
Router Device
Additional Network Segment

Figure 1-1

1.4 Definitions

Common terms are defined in Appendix A, Data Dictionary, of this standard. Certain terms unique to this standard are defined below.

bit. The smallest element of information on the communication channel. *Bits* are grouped into bit fields of one or more bits. A *bit* is of constant time duration set by the signaling rate specified in this standard and has one of two logical values, dominant or recessive. When dominant and recessive levels are impressed on the communications channel at the same time the resulting level is dominant.

bridge. A device that joins two network segments using the same network protocol and address space. Data rate and physical media may differ on the two sides of a *bridge*. A bridge may perform message filtering.

CAN frame/frame. A series of bits transmitted on the communications channel conveying the following types of information:

- *data frame*. Carries data from a transmitter to the receivers.
- *error frame*. Transmitted by a unit detecting a bus error.
- *overload frame*. Transmitted to provide a delay between preceding and succeeding *data frames*.

The CAN data frame has defined start of frame and end of frame bit fields and are separated from preceding fields by an *interframe space*. CAN e*rror* and *overload frames*, when used, are appended directly to the preceding frame without an *interframe space*.

default operation. The operation or settings that exist when standard equipment is first shipped from the manufacturer.

Parameter Group. A set of associated variables, commands, status, or other information to be transmitted on the network. Certain *Parameter Groups*, such as network management messages (e.g., Address Claim message), are defined in the Data Link Layer, Section 3.0, or Network Management, Section 8.0, of this standard. Application related *Parameter Groups* (e.g., GPS data) are defined in the Application Layer section. See Appendix A.

parameter group number. An 8-bit or 16-bit number that identifies each *parameter group*. The *Parameter Group Number* (PGN) is analogous to the three-character sentence formatter in the 61162-1 standard. By definition *Parameter Groups* identified by 16-bit *Parameter Group Numbers* are broadcast to all addresses on the network. *Parameter Groups* identified by 8-bit Parameter Group numbers may be used to direct data for use by a specific address. See Section 3.0 Data Link Layer.

gateway. A device that joins a network to another network or system.

interframe space. A bit field that separates *data frames* from preceding *frames.*

may. The NMEA 2000 standard observes the following convention for the use of word *may* relating to network requirements: Alternatives and optional items that are allowed in this network. An implementation that does not include an alternative shall be prepared to tolerate another implementation that does.

message. A *message* consists of one or more *data frames*, as specified in this standard, that contain the Parameter Group information to be communicated from a *network address*. A message contains the message priority code, *Parameter Group number*, destination *network address*, source *network address*, and data fields. The destination *network address* may be a specific address or global.

network address. The location of a functional entity on the network.

node. The attachment of the physical layer implementation of a transmitter/receiver to the signaling channel. A *node* may represent more than one *network address*.

receiver. A *receiver* is the recipient of a message if the bus is not idle and the device is not a *transmitter.*

router. A device that joins two network segments with the same network protocol. On each side of a *router* address space, data rate and physical media may differ.

shall. standard observes the following convention for the use of word *shall* relating to network requirements: Items that are required in this network.

shall not. The standard observes the following convention for the use of word *shall not* relating to network requirements: Items that are prohibited in this network.

should. The standard observes the following convention for the use of word *should* relating to network requirements: A recommendation that if followed could ease development or improve the operation of the network in some manner.

transmitter. A *transmitter* is the originator of a *message*. The unit remains a *transmitter* until it loses arbitration or until the bus becomes idle.

1.5 Normative References

1.5.1 ISO-11898 - Road Vehicles - Interchange of Digital Information - Controller Area Network (CAN) for High-speed Communications, First Edition November 1993, Amendment 1 April 1994. International Organization for Standardization, Case Postale 56, CH-1211 Genève 20, Switzerland. (Available from ANSI, 11 West 42nd Street, New York, NY 10036.)

1.5.2 Interface Control Document, Navstar GPS Space Segment/Navigation User Interface. Rockwell International Corporation Document No. ICD-GPS-200 Revision B (November 30, 1987)

1.5.3 Special Publication No. 60, User's Handbook On Datum Transformations Involving WGS84, First Edition, June 1994. International Hydrographic Bureau, 7 avenue President J.F. Kennedy, B.P. 445, MC 98011 Monaco Cedex.

1.5.4 ITU Recommendations. International Telecommunications Union, Place des Nations, CH-1211 Geneva 20, Switzerland.

A. ITU-R M.493-7 Digital Selective-Calling System For Use In The Maritime Mobile Service.
B. ITU-R M.821, Optional Expansion of the Digital Selective-Calling System for Use in the Maritime Mobile Service.
C. ITU-R M. 825-1, Characteristics of a Transponder System Using Digital Selective-Calling Techniques For Use With Vessel Traffic Services and Ship-To-Ship Identification.

1.5.5 Institute of Electrical and Electronic Engineers (IEEE): 754-1985 IEEE Standard for Binary Floating-Point Arithmetic. IEEE Standards, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331 USA

1.5.6 "ISO/IEC 10646-1 (1993-05)". "The Unicode Standard, Version 2.0", ISBN 0-201-48345-9, Author: The Unicode Consortium, Publisher: Addison-Wesley. This is equivalent to the standard as to Unicode values and tables.

1.5.7 IEC 60945, Marine Navigational Equipment - General Requirements, Third Edition, November 1996. International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, 1211 Geneva 20, SWITZERLAND

1.5.8 ISO 11783-3. Part 3 Data Link Layer - Tractors and Machinery for Agricultural and Forestry – Serial Control and Communications Data Network . International Organization for Standardization, Case Postale 56, CH-1211 Genève 20, Switzerland. (Available from ANSI, 11 West 42nd Street, New York, NY 10036.)

1.5.9 ISO 11783-5. Part 5 Network Management - Tractors and Machinery for Agricultural and Forestry – Serial Control and Communications Data Network . International Organization for Standardization, Case Postale 56, CH-1211 Genève 20, Switzerland. (Available from ANSI, 11 West 42nd Street, New York, NY 10036.)

1.5.10 GLONASS Interface Control Document, 1995

1.6 Informative References

1.6.1 IEC 61162-1: Digital Interfaces, Maritime Navigation and Radiocommunications Equipment and Systems, International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, 1211 Geneva 20, SWITZERLAND

1.6.2 NMEA 0183 - Standard For Interfacing Marine Electronic Devices, Version 2.30, March 1, 1998, National Marine Electronics Association, PO Box 3435, New Bern, NC 28564-3435, USA

1.6.3 American Practical Navigator, Defense Mapping Agency Hydrographic/Topographic Center, Publication No. 9, DMA Stock No. NVPUB9V1, Volumes I and II

1.6.4 ISO 7498 - Information Processing Systems Open Systems Interconnection (OSI) - Basic Reference Model, International Standards Organization. Available from American National Standards Institute (ANSI) 11 West 42nd Street, New York, NY 10036-8002 USA

1.6.5 SAE J1939 - Recommended Practice for a Serial Control and Communications Vehicle Network. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096

1.6.6 CAN Specification, Version 2.0, Part B, September 1991. Robert Bosch GmbH, D-7000, Stuttgart 1, Germany.

2 Physical Layer

This section defines the electrical and mechanical aspects of the physical link between network connections, and specifies characteristics of the CAN devices and network interfaces to be used in this standard.

The electrical characteristics of the physical layer are dictated by the following network requirements:

- Dominant/recessive bit transmission.
- Differential signaling.
- Network single-point common signal reference.
- Bit rate and network length controlled time delays and network loading.

Differential signaling indicates powered interface circuits and a signal reference common to all nodes on the network. A single-point common reference is specified in order to avoid radio-interference caused by ground loops and to maintain control of ground-voltage levels between nodes such that they remain within the common-mode range (approximately +/-2.5 Volts) of the network transceiver circuits.

The single-point nature of the common signal reference may be achieved in a number of ways as illustrated in Figure 2-1. Single-point power and common may be distributed via the network backbone cable or, for heavier current, by dedicated twisted-pair wires to individual devices. In all cases the power and common for the interface circuits does not connect to other power or ground in a network device. This isolation may be achieved by use of isolation circuits (e.g., optoisolators) within the device or by assuring that no power or ground connections, other than the network power and network common, connect to the device.

Figure 2-2 illustrates a typical physical layer block diagram for a 4-wire (shield not shown) network with an isolated interface and a network power source common to all devices. Ground isolation, illustrated with optoisolators, is shown between the network and the connected device.

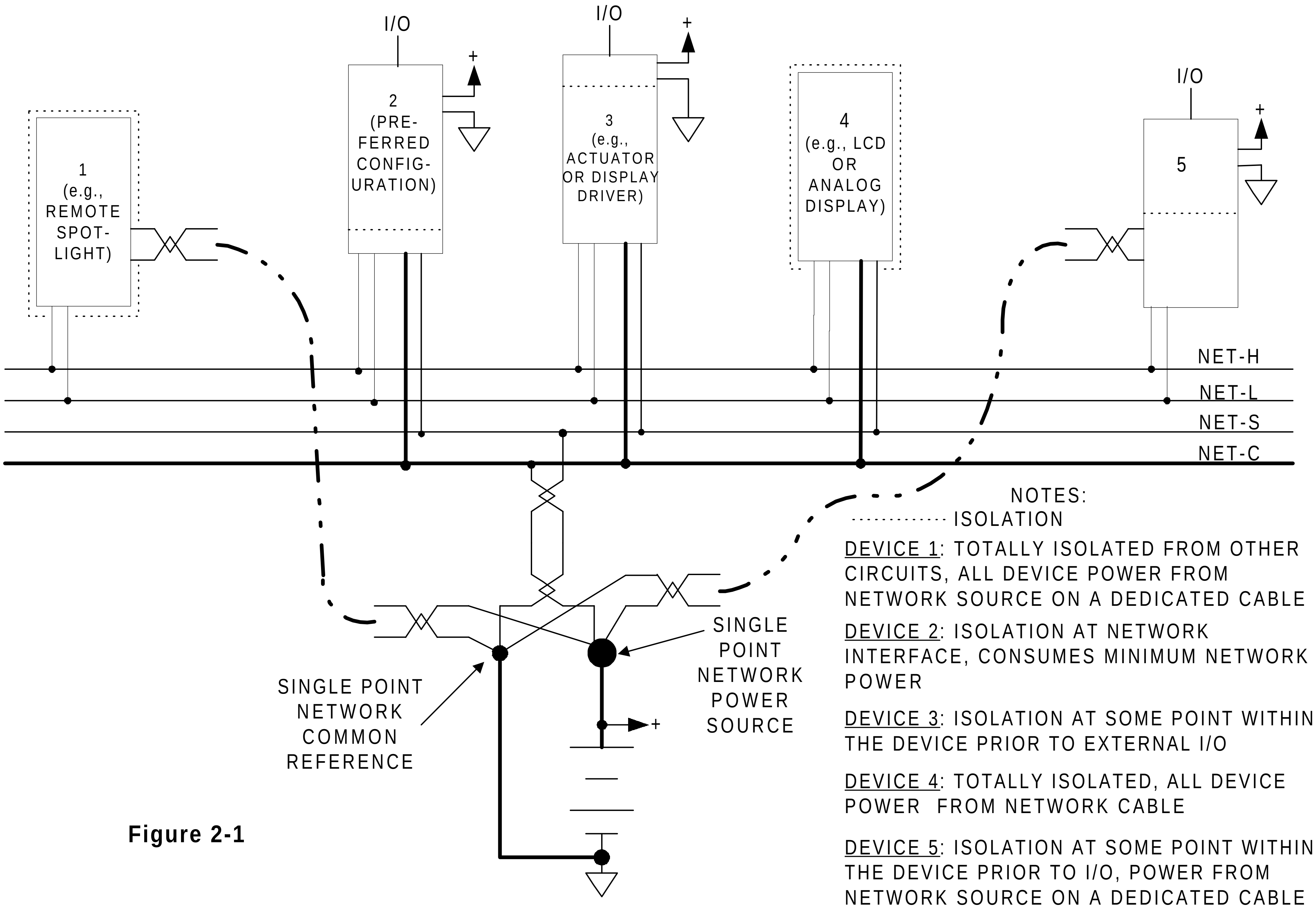
I/O
I/O
I/O
1 (e.g., REMOTE SPOT-LIGHT)
2 (PRE-FERRED CONFIG-URATION)
3 (e.g., ACTUATOR OR DISPLAY DRIVER)
4 (e.g., LCD OR ANALOG DISPLAY)
5
NET-H
NET-L
NET-S
NET-C
SINGLE POINT NETWORK COMMON REFERENCE
SINGLE POINT NETWORK POWER SOURCE
NOTES:
ISOLATION
DEVICE 1: TOTALLY ISOLATED FROM OTHER CIRCUITS, ALL DEVICE POWER FROM NETWORK SOURCE ON A DEDICATED CABLE
DEVICE 2: ISOLATION AT NETWORK INTERFACE, CONSUMES MINIMUM NETWORK POWER
DEVICE 3: ISOLATION AT SOME POINT WITHIN THE DEVICE PRIOR TO EXTERNAL I/O
DEVICE 4: TOTALLY ISOLATED, ALL DEVICE POWER FROM NETWORK CABLE
DEVICE 5: ISOLATION AT SOME POINT WITHIN THE DEVICE PRIOR TO I/O, POWER FROM NETWORK SOURCE ON A DEDICATED CABLE

Figure 2-1

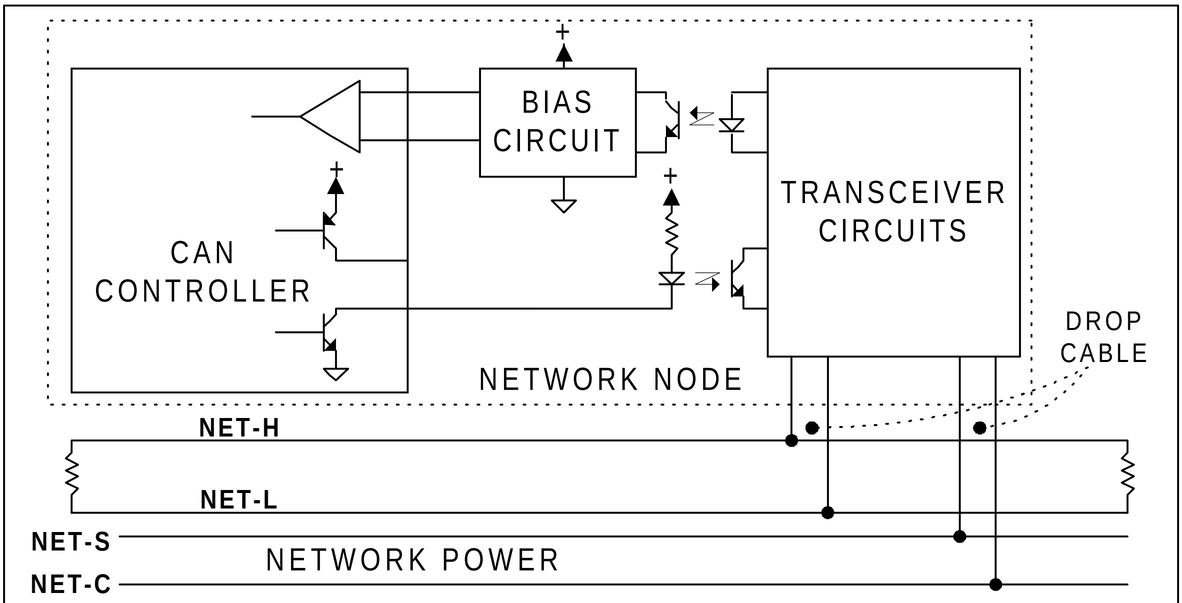

FIGURE 2-2

2.1 General Requirements

2.1.1 Environmental

2.1.1.1 Components and circuits shall be designed to meet the Durability and Resistance to Environmental Conditions for “Exposed Equipment” of IEC 60945 (Third Edition) Section 8. The requirements of Section 8.8 (Rain) apply only to those network components actually intended to be exposed to rain and/or spray.

2.1.1.2 Components and circuits shall be designed to withstand extended storage (non-operating) over the temperature range of -40 to +85°C.

2.1.2 Radio Frequency Interference

2.1.2.1 Components and circuits should be designed to meet the Unwanted Electromagnetic Emission requirements for “Exposed Equipment” of IEC 60945 (Third Edition) Section 9.

2.1.2.2 Components and circuits should be designed to meet the Immunity to Electromagnetic Environment conditions for “Exposed Equipment” of IEC 60945 (Third Edition) Section 10.

2.2 Network Protocol Devices

2.2.1 Controller Area Network (CAN)

The serial communications protocol shall be implemented by integrated circuits (e.g., CAN controllers) meeting the requirements of ISO 11898 – Road Vehicles – Interchange of Digital Information - Controller Area Network (CAN) for

High-speed Communication, using Extended Frames. This specification defines CAN using a 29-bit Identifier field and is included for reference in Appendix D of this standard.

2.2.2 Oscillator Stability

The stability of the oscillator used to derive CAN timing shall be selected for the bit-rate and maximum network length specified in Section 1.3.3 over the operating temperature range. The stability required depends[1] on initialization settings in the CAN device in conformance with the CAN Specification.

2.3 Network Signaling Rate

The network signaling rate shall be 250K bits per second. Automatic bit-rate routines and methods of protecting the network from disruption due to mis-matched bit-rate are being developed and future versions of this standard may allow bit-rates higher or lower than 250K bits per second. These future rates are intended to support high performance, but shorter networks, or longer networks operating at slower speeds. For this reason it is recommended that hardware and software designs are capable of supporting the following rates:

- 1,000 kbits/second - 25 meters
- 500 kbits/second - 75 meters
- 125 kbits/second - 500 meters
- 62.5 kbits/second - 1100 meters

2.4 Electrical Interface

The electrical circuits that interface the CAN controller to the network utilize differential signaling transceiver circuits to convert between network signal levels and CAN controller levels. Signals on the network are either dominant or recessive, functioning as Logic “AND”, with Logic “0” dominant over Logic “1”. DC power to operate the interface circuits is provided by the network (Section 2.4.7), and fault protection circuits within the interface are required to prevent damage from overvoltage and miswiring (Section 2.4.6).

The interface between a device and the network comprises the following four lines:

- NET-H, CAN “High” signal line
- NET-L, CAN “Low” signal line
- NET-S, power source positive
- NET-C, power source common

2.4.1 Shield Connections

It is recommended that shielded cables (Section 2.8) be used to facilitate meeting radio frequency interference requirements. When shielded cables are utilized:

2.4.1.1 The shield shall not be electrically connected within the interface to the electronic device chassis or ground.

---

[1] See “CAN Bit Timing Requirements”, Klaus Dietmayer, Philips Semiconductor and Karl Overberh, Ford Motor Company, SAE ’97 paper (25 February 1997).

2.4.1.2 The shield shall be electrically continuous through the network connection.

2.4.1.3 The shield shall be connected to ground at a single point, normally the ship's ground at the source of network power.

2.4.2 Ground Isolation

2.4.2.1 DC Isolation. Node isolation is determined with the network power and signal cables not connected, but all other node device electrical connections made. The minimum resistance between any terminal in the node's 4-terminal interface circuit and either the ship's ground or voltage source (i.e., ship's battery) shall be greater than100K Ohms.

2.4.2.2 AC Isolation. Node isolation is determined with the network power and signal cables not connected, but all other node device electrical connections made. The minimum reactance between any terminal in the node's 4-terminal interface circuit and either the ship's ground or voltage source (i.e., ship's battery) shall be 100K Ohms at the minimum test frequency of 1.0 MHz.

2.4.3 Network Signaling

The two signal lines carry differential signals with respect to the network power common. Signals on the network represent two states: Dominant state or Logic '0', and Recessive state or Logic '1'. During the transmission of the Dominant state by one or more nodes the state of the network is Dominant.

2.4.3.1 The AC and DC voltage parameters of the network signals shall be as specified by ISO 11898 *Road Vehicles - Interchange of Digital Information, Controller Area Network (CAN) for High-speed Communication*. The nominal voltage levels are:

- Dominant state:
  CAN+ = 3.5V CAN- = 1.5V V_{diff} = CAN+ - CAN- = 2.0V
- Recessive state:
  CAN+ = 2.5V CAN- = 2.5V V_{diff} = CAN+ - CAN- = 0.0V
- Common Mode range:
  Difference in network common voltage between nodes: -2.5 to +2.5 Volts

2.4.3.2 The interface shall be designed such that NET-H and NET-L signal lines are in the Recessive state, or at higher impedance levels, when node power is off.

2.4.4 Signal Time Delays

2.4.4.1 For proper arbitration and to ensure that CAN frames with the ACK bit properly set are sampled from the furthest device on the network, the following timing limit shall be maintained when the sample point is no less than 3/4 into the bit:

$$(3/4)T > 2(L*p_d + CAN_{IN} + CAN_{OUT} + T_X + R_X)$$

Where: T = Bit interval in nano-seconds
L = Length of the network in meters, including drop-lengths, between the

two furthest nodes
p_d = Propagation delay of the cable, ns/meter
CAN_{IN}, CAN_{OUT} = Internal delays of the CAN device, ns
T_X, R_X = Delays of the isolated transceiver circuits, ns

To meet the required network bit rate/length objectives of Section 1.3:

2.4.4.2 The sum of the input timing delays of the physical layer shall not exceed 180 nano-seconds. The input timing delays include all circuit delays from the electronic device's network connector through the CAN device to its bit timing logic unit (e.g., interface receiver delays, opto-isolation circuit delays, and CAN internal input delays).

2.4.4.3 The sum of the output timing delays of the physical layer shall not exceed 180 nano-seconds. The output timing delays include all circuit delays from the CAN device bit timing logic unit to the electronic device's network connector (e.g., CAN internal output delays, opto-isolation circuit delays, and interface transmitter delays).

2.4.5 Interface Schematic Example

Figure 2-3 shows an example schematic diagram of the preferred interface circuit. This circuit illustrates the key points of an electrically isolated interface. The example shows the use of an ISO 11898 compliant transceiver integrated circuit (e.g., Philips PCA82C250, Unitrode UC5350) but other equivalent integrated or discrete circuits designs are possible. Isolation is shown between the CAN interface transceivers and the device circuits, including the CAN controller. High-speed optoisolators are illustrated that provide the interface between the NET-H and NET-L lines of the network and the TX0 and RX0 connections on the CAN controller. For the high-speed operation required in this interface the Slope control line in the example transceiver should be held at less than 1.0 Volt.

The illustrated transceiver circuit requires regulated +5 Volt power that is provided by the Regulator/Protective Circuits. The regulator may be a linear or switching type. The function of the protective circuits is to prevent damage to the regulator and the interface circuits from overvoltage and reverse voltage. It is important to note that it may be necessary to protect the transceiver circuit ground from high reverse voltage, the transceiver ground is indicated as a separate wire from network common (NET-C).

Not shown are details of the CAN controller connections, including CAN input bias requirements unique to the selected CAN Controller. Standard engineering practice for the design of high-speed digital circuits should be applied (e.g., power supply bypass filtering, and physical separation of the two ground systems).

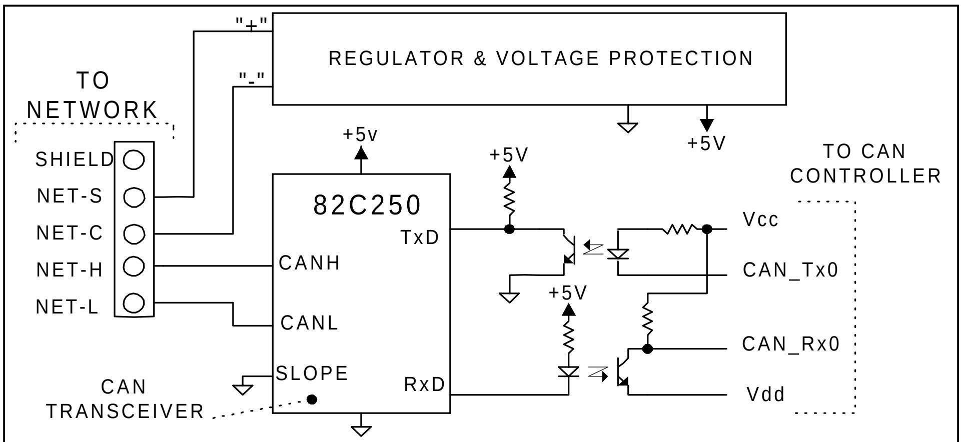

FIGURE 2-3

2.4.6 Interface Protection

In addition to meeting the electromagnetic immunity requirements of Section 2.1.2 the interface circuits and the electronic device connected to the network are required to withstand overvoltage and wiring errors.

2.4.6.1 No permanent damage shall result from a voltage level of +/-18.0 Volts or less applied between any two wires in the interface for an indefinite period of time.

2.4.6.2 No permanent damage shall result from miswiring the interface lines in any combination for an indefinite time.

2.4.7 Interface Power

To minimize the complexity of the interface, while maintaining isolation from other device power and grounds, power for the operation of the interface circuits is provided by a network power source. To further minimize interface and wiring complexity, network power may be used, within the limits specified, to operate other circuits in the node in addition to the interface circuits. These additional circuits may include the CAN controller, microprocessors and peripherals, and other device loads.

As shown in Figure 2-1 various methods may be employed to isolate network power and common from other device power and ground connections. In some applications devices may take all operating power from the network power source, either from the backbone cable or a dedicated power cable, and achieve isolation by isolated packaging and mounting provisions (devices 1 and 4 in Figure 2-1). Other devices may take all, or the majority, of operating power from the network power source and provide simple isolation circuits at the input or output to other equipment such as actuators, etc. (devices 3 and 5 in Figure 2-1).

2.4.7.1 The interface shall operate over the range of 9.0 to 16.0 Volts DC.

2.4.7.2 Node power and common shall either be supplied from the network backbone cable and drop cable or supplied by a dedicated node power cable connected only between a single node and the network power/common source (battery or one power supply).

2.4.7.2.1 When connected to the network backbone power source the node current shall not exceed 1.0 Amp including high-speed transients.

2.4.7.2.2 When a node is connected by a dedicated node power cable the connections for network power and common shall be physically separated and electrically isolated from other power and ground connections, if any, on the equipment.

2.4.7.2.3 When a node is connected by a dedicated node power cable the connections for network power and common shall be clearly labeled according to Table 2-1. The maximum peak node current for this configuration is not specified by this standard.

Table 2-1 Network Power Labeling

Name	**Label**
Positive	NET-S
Common	NET-C

2.4.7.3 The instantaneous peak value of the common voltage of all receivers with respect to any transmitter shall be within the common-mode voltage range of the ISO 11898 equivalent transceiver.

2.4.7.4 Node power and common shall not be electrically connected to other power or ground sources in the node.

2.4.7.5 Node power and common currents should be carried in twisted pair wires and shall be balanced (i.e., the return current contains the same current components supplied by the node power source).

2.4.7.6 The manufacturer shall specify the power rating for each connected device as a "load equivalency number" for use in planning network installations. One Network Load is defined as 50 mA or any portion thereof (e.g., a device taking 51 mA from the network power bus is a Two Network Load device).

2.4.7.7 Devices connected to network power shall not introduce noise, ripple, or transients on the network power source in excess of levels allowed by Section 9.2 Conducted Emissions of IEC 60945 (Third Edition).

2.4.7.7.1 For frequencies less than 10KHz conducted emissions shall be less than 0.25 Volts peak-to-peak.

2.4.7.8 Reaction to power disturbances shall be in accordance with ISO 11783-5, see Appendix B.

2.5 Network Power Source

The power source shall be either a single-point connection to the vessel's battery or one or more isolated power supplies distributed along the network, but not a combination of battery and power supply connections.

The maximum length of the network and the number of nodes that can be connected are constrained by limitations associated with data transmission and with DC power distribution. As the number of nodes with power requirements beyond that needed for an isolated interface increase, power distribution quickly becomes the limiting factor. For networks of shorter length and with a lower number of connected devices the ship's battery may be used to power the network nodes directly. In place of the battery multiple electrically isolated regulated power supplies may be used if it is necessary to extend the size of the network.

Tables 2-2 through 2-4 illustrates device number limitations due to the DC drop in the network power cable. These figures illustrate certain extremes of installation configurations. Table 2-2 describes limitations when the power supply is at one end of the backbone cable and all devices are at the opposite end. Network length limitations for a distributed system with the power supply located midway among equally distributed devices is shown in Table 2-3. Table 2-4 illustrates the limitations when the ship's battery powers the network directly.

Appendix E provides applications information with suggestions for cable selection and the strategic location of a single battery connection or (multiple) power supply(s), and an installation worksheet.

2.5.1 Network Power Supply

2.5.1.1 DC Ground Isolation. Isolation is determined with the network power cables not connected, but all other power supply electrical connections made. The minimum resistance between the NET-S and NET-C terminals on the power supply and the power supply chassis, the ship's ground, and the ship's voltage source (i.e., ship's battery) shall be greater than 100K Ohms.

2.5.1.2 Output voltage of the power supply shall be 15 Volts +/-5% over the full combined range of output load and input line variation.

2.5.1.3 Input line variation range for AC operated power supplies shall be +/-10% of the nominal AC Voltage value and +/-6% of the nominal 50 or 60 Hz line frequency.

2.5.1.4 Input line variation for DC operated power supplies shall be +30% to -20% of the nominal 12.0, 24.0 Volt, or other DC values.

2.5.1.5 The minimum output current capacity shall be specified by the manufacturer under the least favorable combination of input line value and output voltage and over the specified network operating temperature range.

2.5.1.6 Output current surge capacity of 125% of the manufacturer's specified capacity shall be provided for a duration of at least 1.0-second.

2.5.1.7 Output ripple shall be 0.25 Volts p-p or less.

2.5.1.8 Output overvoltage protection shall be provided to limit the output voltage to 18.0V.

2.5.1.9 Output overcurrent protection shall be provided to limit current to 150% of the manufacturer's specified capacity without requiring the replacement of fuses or resetting of circuit breakers.

2.5.1.10 The power supply shall operate with additional power supplies attached to the network and shall not sink current from power supplies with a higher output voltage.

2.5.1.11 The power supply shall have provision for attachment of the network shield to ship's ground. In multiple power supply configurations the shield connection should be made at only one power supply (single-point ground).

Table 2-2 - Wire Gauge and Bus Length: End-located power supply with all devices at opposite end

Wire type	Resistance (m/Ohm)	Max V drop (Volts)	Bus Length (meters)	Total R (Ohms)	Max I (Amps)	Max # of Electronic Devices (**200**mA/device)
16 gauge	75	6	200	5.32	1.1	5
14 gauge	120	6	200	3.33	1.8	9
12 gauge	192	6	200	2.08	2.8	14
16 gauge	75	6	22.6	0.60	10.0	50
14 gauge	120	6	36	0.60	10.0	50
12 gauge	192	6	57.5	0.60	10.0	50

Table 2-3 - Wire Gauge and Bus Length: Center-located power supply and distributed devices

Wire type	Resistance (m/Ohm)	Max V drop (Volts)	Bus Length (meters)	Total R (Ohms)	Max I (@ PS) (Amps)	Max # of Electronic Devices (**200**mA/device)
16 gauge	75	6	200	2.63	8.6	43
14 gauge	120	6	200	1.66	14.0	70
12 gauge	192	6	200	1.04	22.6	113
16 gauge	75	6	175	2.31	10.0	50
14 gauge	120	6	278	2.31	10.0	50
12 gauge	192	6	443	2.31	10.0	50

$n = 2[(\Delta e/i)(m/\Omega)(2/d)-1]$

n = total number of nodes
Δe = max. voltage drop
i = current per node
m/Ω = cable meters/Ohm
d = total backbone length

o Single 15-volt bus power supply
o Network interface operating range: 9 to 16 volts
o Copper wire @ 20C, drop cable and connector resistance's ignored

Table 2-4 - Wire Gauge and Bus Length: Center-located ship's battery and distributed devices

Wire type	Resistance (m/Ohm)	Max V drop (Volts)	Bus Length (meters)	Total R (Ohms)	Max I (@ Battery) (Amps)	Max # of Electronic Devices (**500**mA/device)
16 gauge	75	2	50	0.66	11	22
14 gauge	120	2	50	0.41	18	36
12 gauge	192	2	50	0.26	30	59
16 gauge	75	2	55	0.73	10.0	20
14 gauge	120	2	88	0.73	10.0	20
12 gauge	192	2	140	0.73	10.0	20

o End of battery life = 11.0 Volts
o Network interface operating range: 9 to 16 volts
o Copper wire @ 20C, drop cable and connector resistance's ignored

2.6 Network Termination

Networks shall have two termination resistors to reduce transmission-line reflections, one at each end of the linear network backbone cable.

2.6.1 Termination resistors shall be 120 Ohms +/-5%, ¼ Watt minimum power dissipation rating.

2.6.2 In order to minimize network disturbance when nodes are disconnected from the network, termination resistors shall be connected only to the ends of the main network backbone cable and not to cable drops leading to an electronic device and not within electronic devices.

2.7 Connectors

A network consists of lengths of network backbone cable with a defined beginning and end. A resistive termination is connected at each end. Connections for power supplies electronic devices (nodes) may be inserted along the length of the network cable.

2.7.1Electronic Device Connectors

Electronic devices may be connected to the network backbone cable either directly or by means of a short drop cable. When drop cables are used to connect to the network backbone cable the connections at the electronic device are not specified by this standard.

a) When network connections are made internally through a node the pass-through shall not include active components (passive pass-through).
b) When the network backbone cable is connected directly to the electronic device the connections shall meet the network connections requirements of this standard.
c) If network connectors are used there shall be one of each type, plug and socket, such that the network cable may be rejoined when the electronic device is removed from the network.
d) If barrier strips are used they shall be of a plug and socket type such that network operation may continue without the need to disconnect and re-connect individual wires in the network cable.

2.7.2 Power Supply Connectors

Power supply or battery connections may be made to the network backbone cable either directly or by means of a dedicated cable. When dedicated cables are used to connect to the network backbone cable, the connections at the power source are not specified by this standard.

a) When the network backbone cable is connected directly to the power source the connections shall meet the network connections requirements of this standard.
b) If network connectors are used there shall be one of each type, plug and socket, such that the network cable may be rejoined when a power source is removed from the network.
c) If barrier strips are used they shall be of a plug and socket type such that network operation may continue without the need to disconnect and re-connect individual wires in the network cable.

2.7.3 Network Connections

The network backbone cable contains connections for: electronic devices (nodes), drop cables to nodes, cables to network power sources, and for termination resistors. One of two methods of connecting to the network backbone cable shall be used. The two methods are allowed for all types of connections and may be used together on the same network:

- Barrier strips, and/or
- Standardized 5-pin connectors

2.7.3.1 Barrier Strips

Barrier strips should only be used in protected locations, or enclosed in weatherproof housings, and a means for cable strain relief should be provided.

2.7.3.1.1 Barrier strips intended for use in exposed locations shall meet the Durability and Resistance to Environmental Conditions for “Exposed Equipment” of IEC 60945 (Third Edition) Section 8, including Section 8.8 (Rain).

2.7.3.1.2 Radiated interference due to the use of barrier strips shall not exceed the limits defined by Section 2.1.2 Radio Frequency Interference.

2.7.3.1.3 Barrier strip electrical connection materials should be corrosion resistant (e.g., nickel plated brass, stainless steel)

2.7.3.1.4 Barrier strips shall provide connections for the five network lines for both directions of the network cable and for the electronic device drop cable.

2.7.3.1.5 When used for termination resistors all five wires shall be attached to the barrier strip and the termination resistor connected between NET-H and NET-L, no connections are allowed to the other three terminals.

2.7.3.1.6 When barrier strips are used it shall be possible to disconnect the electronic device from the network without disconnecting individual wires.

2.7.3.1.7 Wire connections to barrier strips shall be made with threaded fasteners.

2.7.3.1.8 Barrier strips shall be color coded, or labeled with the wire number, and the connections made the order shown in Table 2-5:

Table 2-5 Barrier Strip Wiring

Name	Number	Color
Shield	1	bare
NET-S	2	Red
NET-C	3	Black
NET-H	4	White
NET-L	5	Blue

2.7.3.2 Connectors

Connectors used with the network backbone perform the following functions:

a) Allow termination resistors to be connected at the ends of the cable,
b) Allow electronic devices and power supplies to be connected into the cable, and
c) Allow the network cable to be joined if the length is to be extended, or to be rejoined if a device is removed from the cable.

2.7.3.2.1 Connectors shall be the 5-pin “Mini” style connectors compatible with industrial bus systems (e.g., DeviceNet™, Profibus™, and SDS™).

2.7.3.2.2 Connectors shall be sealed at the threads and at the cable entry and meet the Durability and Resistance to Environmental Conditions for “Exposed Equipment” of IEC 60945 (Third Edition) Section 8, including Section 8.8 (Rain).

2.7.3.2.3 The network end of the drop cable and power supply cable shall have male pins and external threads on the connector housing.

2.7.3.2.4 Lengths of a network backbone cable using two connectors shall have male pins and external threads on the connector housing on one end and female sockets and internal threads at the other end.

2.7.3.2.5 Connectors used to mount termination resistors shall have the termination resistor connected between NET-H and NET-L, no connections are allowed to the other three terminals.

2.7.3.2.6 When used in exposed locations the termination resistor connections shall meet the Durability and Resistance to Environmental Conditions for “Exposed Equipment” of IEC 60945 (Third Edition) Section 8, including Section 8.8 (Rain).

2.7.3.2.7 When termination connectors are used at both backbone cable ends (vs. barrier strips) one-termination connector shall be male and the other female. Following this practice allows for future lengthening of the network backbone cable.

2.7.3.2.8 Cable wires using the recommended colors shall be attached to the connector pins as shown in the Table 2-6:

Table 2-6 Connector Wiring

Name	**Number**	**Color**
Shield	1	bare
NET-S	2	Red
NET-C	3	Black
NET-H	4	White
NET-L	5	Blue

2.7.3.2.9 When the recommended colors are not used a permanent label shall be attached to the cable indicating the color code in use.

2.7.3.2.10 Insertion of a node into the network backbone cable shall be made using compatible “T” connectors or junction boxes fabricated using compatible bulkhead style connectors.

2.7.3.2.11 Network “T” connectors and junction boxes shall have all five wires from each connector wired in parallel.

2.8 Network Cable

Two types of cable may be used in a network, heavy and light. The selection of cable type for various portions of the network depends on the number of Network Loads attached, the length of the network cables, and the location of the specific cable in the network. Appendix E provides applications information with suggestions for cable selection and the strategic location of (multiple) power supply(s), and an installation worksheet.

2.8.1 Heavy Cable

This cable has the electrical characteristics of the type used with industrial bus systems (e.g., DeviceNet™, Profibus™, and SDS™). Heavy Cable used in applications of this standard have the following characteristics:

2.8.1.1 Heavy cable may be five-wire constructed with two individually twisted-shielded pairs enclosed by an overall shield with a shield drain wire connecting all three shields. The optional shields may be foil or braid.

2.8.1.2 The five wires shall be stranded-copper with each strand individually tinned to improve corrosion resistance.

2.8.1.3 The heavy pair used for network power shall be No. 16 AWG (1.33 sq. mm) or heavier.

2.8.1.4 The heavy twisted-pair used for signals shall have the following electrical characteristics:

1. Size: No. 18 AWG (0.83 sq. mm) or heavier,
2. Characteristic impedance: 95 - 140 Ohms,
3. Propagation delay: 5 nanoseconds per meter, maximum,
4. 10 Twists per meter.

2.8.1.5 The heavy cable drain wire shall be No. 18 AWG (0.83 sq. mm) or heavier.

2.8.1.6 Insulating materials shall be oil and fuel resistant and capable of withstanding -40 to +85°C.

2.8.1.7 When the recommended wire colors shown in Table 2-7 are not used the cable shall be permanently labeled to indicate the color code in use:

Table 2-7 Heavy Wire Color Code

Name	Pair	Color
Shield	drain	bare
NET-S	power	Red
NET-C	power	Black
NET-H	signal	White
NET-L	signal	Blue

2.8.2 Light Cable

This cable has the electrical characteristics of the type used with industrial bus systems (e.g., DeviceNet™, Profibus™, and SDS™). Light cable used in applications of this standard have the following characteristics:

2.8.2.1 Light cable may be five-wire constructed with two individually twisted-shielded pairs enclosed by an overall shield with a shield drain wire connecting all three shields. The optional shields may be foil or braid.

2.8.2.2 The five wires shall be stranded-copper with each strand individually tinned to improve corrosion resistance.

2.8.2.3 The light pair used for network power shall be No. 22 AWG (0.38 sq. mm) or heavier.

2.8.2.4 The light pair used for signals shall have the following electrical characteristics:

1. Size: No. 24 AWG (0.24 sq. mm) or heavier,
2. Characteristic impedance: 95 - 140 Ohms,
3. Propagation delay: 5 nanoseconds per meter, maximum,
4. 15 Twists per meter.

2.8.2.5 The light cable drain wire shall be No. 22 AWG (0.38 sq. mm) or heavier.

2.8.2.6 Insulating materials shall be oil and fuel resistant and capable of withstanding -40 to +85°C.

2.8.2.7 When the recommended wire colors shown in Table 2-8 are not used the cable shall be permanently labeled to indicate the color code in use:

Table 2-8 Light Wire Color Codes

Name	Pair	Color
Shield	drain	bare
NET-S	power	Red
NET-C	power	Black
NET-H	signal	White
NET-L	signal	Blue

3 Data Link Layer

The Data Link Layer is international standard ISO 11783-3 with additional provisions and requirements as described in this section. ISO 11783-3 is titled Tractors and Machinery for Agricultural and Forestry, Serial Control and Communications Data Network – Part 3 Data Link Layer and is included for reference in Appendix B of this standard.

1. When there are differences between the ISO 11783-3 specification and this standard, then this standard shall be the guiding document.
2. ISO 11783-3 refers to vehicle, tractor, trailer, implements, machinery, forestry or agricultural equipment, etc. this standard relates to boats and vessels.
3. When ISO 11783-3 refers to an ISO network this is construed to also include networks based on this standard.

ISO 11783-3 is harmonized with the Society of Automotive Engineers SAE J1939-21 Recommended Practice for a Serial Control and Communications Vehicle Network – Part 21 – Data Link Layer.

3.1 Fast-packet Messages

ISO 11783-3 provides for the transfer of single-frame messages and multi-packet messages containing from 8 to 1785 data bytes. Multi-packet message transfers utilize the Data Transfer Transport Protocol (PGN 60160) and the Connection Management Transport Protocol (PGN 60416). Multi-packet protocols require the identity of the Parameter Group being transferred (PGN) be contained in the data fields (vs. CAN Identifier field), require flow control (Connection Management), and the insertion of a minimum inter-frame space of 50 ms for broadcast messages using PDU2 Format.

This standard in addition defines a fast-packet message transfer of up to 223 bytes of data without use of a transport protocol and without a required inter-frame space beyond that specified in the CAN specification (ISO 11898). Fast-packet Parameter Groups are defined at the Parameter Group design stage and the PGN is contained in the Identifier field of each message in the same manner as a single-frame message.

ISO 11783-3 defines the number and type of connections a node must support. This standard adds the Fast-packet message to the number and type of connections that a node must support. The minimum requirement is to support the concurrent reception of the following messages:

- One fast-packet message
- One multi-packet Broadcast message
- One multi-packet RTS/CTS session

3.1.1 Fast-packet Protocol

1. The first frame of a fast-packet message shall contain:
   a) Identifier field according to ISO 11783-3:
      - Message priority, Reserved bit, and Data Page bit
      - Parameter Group Number identifying the PG being transmitted
      - Destination address if the message is directed to a single address, global otherwise
      - Source address of the sender

   b) Data field:
      - Byte 1:
        - $b_0 – b_4$ = 00000, b_0 =LSb
        - $b_5 – b_7$ = 3-bit sequence counter to distinguish separate fast-packet messages of the same PGN, b_5 is the LSB of the counter.
      - Byte 2 = Total number of data bytes to be transmitted in the message (0 to 223). This number includes up to (6) data bytes in the first frame and up to (7) data bytes in following frames.
      - 6-bytes of transmitted data
2. Additional frames, up to a maximum of 31, shall contain the following:
   a) 29-bit Identifier field according to ISO11783-3:
      - Message priority, Reserved bit, and Data Page bit
      - Parameter Group Number identifying the PG being transmitted
      - Destination address if the message is directed to a single address, global otherwise
      - Source address of the sender

   b) Data field:
      - Byte 1:
        - $b_0 – b_4$ = 1 to 31, 5-bit frame counter
        - $b_5 – b_7$ = 3-bit sequence counter set to value in first frame.
      - 7-bytes of transmitted data
      - Unused bits in the last frame of a fast-packet message shall be filled with logic “1” bits.

3.1.2 Fast-packet Usage

1. Parameter Groups not defined as single-frame (see Appendix A) shall always be transmitted as either fast-packet according to this standard or by use of the multi-packet transport protocol according to ISO 11783-3.
2. Parameter Groups not defined as single frame shall not be transmitted without using the first two bytes of the first frame to indicate frame count, sequence counter, and message size even if the message size is 8-bytes or less.
3. The modulo 7 sequence counter shall increment each time the same PGN is transmitted from the same source address.
4. A separate sequence counter shall be utilized for each different PGN

transmitted from the same source address.

5. Fast-packet messages of the same PGN may be transmitted at intervals of less than 100 Ms, see ISO 11783-3 Figure 4.
6. Successive fast-packet frames may be transmitted without additional inter-frame delays.
7. Successive new fast-packet messages from the same source address shall be separated in time by a minimum of (10) CAN frames.
8. A fast-packet message shall not be considered as incomplete until a time-out of 750 ms from the last received frame occurs.
9. If not single-frame, when a Parameter Group designed as PDU2 format (using the Group Extension) is transmitted to a specific address, it shall be sent using the ISO 11783-3 Transport Protocol.

3.2 Request/Command/Acknowledgment Messages

ISO 11783-3 provides Request PGN 59904 for the purpose of requesting that a specific device (addressed) or all devices (global) transmit the Parameter Group specified in the data field of the PGN 59904 Request message. No additional request instructions are provided.

The normal reply to a request message is the data requested. ISO 11783-3 provides the Request Acknowledgment parameter group (PGN 59392) for use when required by the Application Layer (e.g., in response to a command message) or when the data requested by PGN 59904 is not sent. This acknowledgment message provides only minimum information when the result is a NACK and provides for only a single Group Function field.

This standard additionally requires the use of the Request-Command-Acknowledgment parameter group (PGN 126208) defined in Appendix A . This is a Group Function parameter group that utilizes the first data field of the message to indicate the function of the message. Three functions are provided:

a) Complex Request message, for requesting data, setting transmission timing, and for specifying variables in the request message,
b) Command message to set variables or initiate processes in a device, and
c) Expanded Acknowledgment message to confirm actions or to indicate reasons that a request or command message cannot be complied with.

3.2.1 Complex Data Request Group Function Message

Complex Data Request Group Function (PGN 126208) is a fast-packet message requesting that a specifically addressed device, or all devices (global), transmit the requested Parameter Group repeatedly at a specified interval and a specified offset time. In addition the Complex Data Request is capable of specifying variables associated with the data being requested (e.g., the location of a stored waypoint may be requested by the field containing the waypoint name).

The use of the Complex Request message will vary from application to application. For example if a device had been requested to transmit GPS position fix data at a certain interval and another device requests a different interval the rate would be changed. On the other hand if a tracking radar had been requested to transmit Target No. 37 range and bearing at a three-second interval and a new request is received to send Target No. 43 at a four-second interval then both targets would be transmitted at three and four second intervals respectively.

The Complex Request Group Function message contains:

- Group Function code set to 0x00 indicating this message is a Complex Data Request.
- PGN of the requested information.
- Requested transmission interval
- Requested offset of transmission from time of request
- Number of request parameter pairs in following fields.
- Multiple pairs of fields specifying the field number and the parameter value for Parameter Groups that have selectable parameters. The field numbers and types of parameter values in the Complex Data Request message match the allowed request parameter fields in the requested Parameter Group. The fields requested may occur in any order in the message.

1. All devices shall support the Complex Request Group Function message.
2. The Complex Request Group Function message shall be implemented as described in Appendix A.
3. Compliance with the request (i.e., to send the requested data, and set transmission intervals and offsets) is optional.
4. All devices shall be capable of acknowledging a Complex Request message addressed to it. The acknowledgment is the data requested or the Expanded Acknowledgment message containing the appropriate error codes.
5. When a device supports the a PGN containing checked (√) Request Parameter fields (see Appendix A Section A-1.) it shall at a minimum support requests specified by those fields.
6. ISO 11783-3 Request message (PGN 59904) may be used when requesting a single data transmission without altering transmission-timing variables.
7. Devices shall support a Global Complex Data Request message requesting the Address Claim PGN 60928 and reply with the Address Claim parameter group when the Parameter Request fields contain no information (null) or when the contents of these fields match those of the device for any of the following fields (see Device Information Section 8.3):

- Industry Group
- Device Class field
- Function field
- Manufacturer's Code field

3.2.2 Command Group Function Message

The Command Group Function message (PGN 126208) may be used to set variables within a device or to command changes of state. The Command Message accommodates multiple variables simultaneously and utilizes flexible command fields matching the format of the variable fields of the Parameter Group containing the variables being controlled.

The Command Group Function message contains:

- Group Function code set to 0x01 indicating this message is a Command message.
- PGN of the message containing the fields being commanded.
- Number of commanded parameter pairs in following fields.
- Multiple pairs of fields specifying the field number and the parameter value for Parameter Groups that have commandable parameters. The field numbers and types of parameter values in the Command message match the allowed request parameter fields in the requested Parameter Group. The fields commanded may occur in any order in the message.

1. All devices may optionally support commands contained in the Command Group Function message.
2. The Command Group Function message shall be implemented as described in Appendix A.
3. This message shall only be addressed to a specific address.
4. The Expanded Acknowledgment Group Function message shall be transmitted in response to each Command Message indicating acknowledgment or containing the appropriate error code.

3.2.3 Expanded Acknowledgment Group Function Message

The Expanded Acknowledgment Group Function parameter group (PGN 126208) is a fast-packet message sent to the specific address that originally issued a request or command.

The Expanded Acknowledgment reply supports more than one request parameter per message and provides information regarding the inability to comply with a request or command:

- PGN not supported
- Access denied. PGN, timing, and parameters otherwise supported

- PGN temporarily not available
- Transmit interval not supported
- Transmit interval is less than measurement/calculation interval
- Invalid request or command parameter field
- Unable to comply
- Request or command parameter out-of-range
- Request or Command Group Function not supported
- Access denied

The Expanded Acknowledgment Group Function message contains:

- Group Function code set to 0x02 indicating this message is the Expanded Acknowledgment message.
- PGN error code.
- Transmission interval error code.
- Variable number fields providing error codes relating to request or commanded parameters.

1. All devices shall support the Expanded Acknowledgment Group Function message.
2. The Expanded Acknowledgment Group Function message shall be implemented as described in Appendix A.
3. The Expanded Acknowledgment message shall not be used in response to Global requests.
4. An Expanded Acknowledgment message, when required, shall be transmitted within 1 second of receiving the request or command.

3.3 ISO 11783-3 Requirements

Table 3-1 summarizes the recommendations (e.g., "recommended", "should", and "may" terminology) in ISO 11783-3 that are requirements of this standard. The terminology "will/will-not and must/must-not" used in ISO 11783 is considered equivalent to the terminology "shall/shall not" used in this standard.

Table 3-1 ISO 11783-3 Requirements	
3.2.2 Reserved Bit ®	All messages shall set the reserved bit in the CAN ID field to zero on transmit.
Transport Protocol, Connection Management PGN 60416	Data field reserved bytes shall be filled with FF_{16}
Transport Protocol, Data Transfer PGN 60160	Data field extra bytes shall be filled with FF_{16}
Appendix B, ACK	If the PGN in a Command or Request is not recognized by the destination it shall reply with the ACK message.

3.4 Proprietary Messages

Different PGNs are used in order to distinguish between single-frame and fast-packet proprietary messages. By definition, those proprietary PGNS that are single frame shall have a higher priority than page 1.

3.4.1 Single-Frame Proprietary

Single-Frame Proprietary messages shall use ISO 11783 PGNs 61184 (addressable) and 65280 ... 65535 (broadcast) from page 0. These are defined by ISO 11783 to be single frame unless they are sent multi-packet.

3.4.2 Fast-Packet Proprietary

Fast-Packet Proprietary messages shall use PGNs 126720 (addressable) and 130816 ... 131071 (broadcast) from page 1.

OSI Network Layer Requirements

Defines how data is routed through a network from source to destination and may find utility if bridges, routers, or gateways are utilized to connect network segments or systems, or if multiple paths are provided. The deterministic characteristic of CAN may be degraded in network segment communications using router devices and real-time control applications between network segments may not be supported.

(To be developed at a later time.)

4 OSI Transport Layer Requirements

Not presently applicable to this standard. The minimum necessary elements of this layer are provided by the Application layer or Logical Link Control sub-layer.

5 OSI Session Layer Requirements

Not presently applicable to this standard. The minimum necessary elements of this layer are provided by the Application layer or Logical Link Control sub-layer.

6 OSI Presentation Layer Requirements

Not defined by this standard. The minimum necessary elements of this layer are provided by the Application layer or Logical Link Control sub-layer.

7 Network Management

The specification for network Management is international standard ISO 11783-5 with additional provisions and requirements as described in this section. ISO 11783-5 is titled Tractors and Machinery for Agricultural and Forestry, Serial Control and Communications Data Network – Part 5 Network Management and is included for reference in Appendix C of this standard.

1. When there are differences between the ISO 11783-5 specification and this standard , then this standard shall be the guiding document.
2. When ISO 11783-5 refers to vehicle, tractor, trailer, implements, machinery, forestry or agricultural equipment, etc. this standard relates to boats and vessels.
3. When ISO 11783-5 refers to an ISO network this is construed to also include any network based on this standard.

ISO 11783-5 is harmonized with the Society of Automotive Engineers SAE J1939-81 Recommended Practice for a Serial Control and Communications Vehicle Network – Part 81 – Network Management.

7.1 Address Configurability

ISO 11783-5 allows four categories of address configurability: non-configurable, service configurable, command configurable, and self-configurable.

1. Devices shall be capable of self-configurable addressing.
2. Non-configurable devices shall not be used on this network.
3. Devices may be optionally capable of accepting a commanded address from a System Tool (see Table 8-1).

Note:
Self-configuring addressing procedures are described in ISO 11783-3 and allow a device's address to be claimed by another device with a NAME field of higher priority. Future testing of these procedures will be performed and the effect on network performance will be analyzed. Changes to these procedures are possible. Designers of network applications involving real-time control should be aware of the potential impact on real-time control during address re-assignment procedures.

7.2 Device Information

ISO 11783-5 defines the Address Claimed message PGN 60928 with a data field containing NAME. NAME is a 64-bit entity that in addition to reserved bits includes:

- Industry Group
- Device Class Instance
- Device Class (Navigation, Machinery Control, Fire Protection System, Cargo Monitoring System, etc.)

- Function (Dependent on Device Class)
- Function Instance
- Device Instance
- Manufacturer Code
- Unique Identity Number

a) Devices shall implement the NAME field, and field dependencies of the Address Claim message as defined by PGN 60928 in Appendix A database file "2000vx.x.mdb".
b) Device Class (field 4) and Function (field 6) of the NAME data fields of PGN 60928 shall be implemented according to Table 8-1.

Table 8 – 1 - Device Class and Function Code Assignment			
Device Class		**Function**	
Class Code	**Class Name**	**Function Code**	**Function Name**
00	Reserved for this standard use		
10	System tools	TBD	TBD
20	Safety systems	TBD	TBD
30	Power management and lighting systems	TBD	TBD
40	Steering systems	10	Follow-up Controller
		20	Mode Controller
		30	Heading Track Controller
50	Propulsion systems	10	Engineroom monitoring
60	Navigation systems	10	Sounder, depth
		20	Heading Sensors
		25	Global Navigation Satellite System (GNSS)
		30	Loran C
		35	Speed Sensors
		40	Turn Rate Indicator
		50	Integrated Navigation
		80	Radar and/or Radar Plotting
		85	Electronic Chart Display & Information System (ECDIS)
		90	Electronic Chart System (ECS)
		100	Direction Finder
70	Communications systems	10	Emergency Position Indicating Beacon (EPIRB)
		20	Automatic Identification System
		30	Digital Selective Calling (DSC)
		40	Data Receiver
		50	Satellite
		60	Radio-Telephone (MF/HF)
		70	Radio-Telephone (VHF)
80	Instrumentation/general systems	10	Time/Date systems
		20	Voyage Data Recorder
		30	Integrated Instrumentation
		40	General Purpose Displays
		50	Weather Instruments
		60	Transducer/general
90	Environmental (HVAC) systems	TBD	TBD
100	Deck, cargo, and fishing equipment systems	TBD	TBD

In addition to the information defined by NAME, this standard provides additional Product Information and Configuration Information Parameter Groups.

7.2.1 Product Information

The Product Information parameter group (PGN 128768) includes:

- IEC 61162-3 edition supported
- Manufacturers model number code
- Manufacturers product version code
- Manufacturers software version code

1. All devices shall support the Product Information message containing at a minimum the “IEC 6162-3 edition Supported” data field.
2. The Product Information message shall be implemented as described in Appendix A.

7.2.2 Configuration Information

The Configuration Information parameter group (PGN 128769) includes:

- Free-form field describing the installation location of the device.
- Free-form field providing field notes.

1. Devices may optionally support the Configuration Information message.
2. When implemented the Configuration Information message shall be implemented as described in Appendix A.

7.3 Transmitted/Received PGN List Group Function

A feature of the network management is the ability of a device to compile a list of both transmitted and received Parameter Groups that are supported by other devices. The Transmitted/Received PGN List Group Function (PGN 126464) is a Group Function parameter group that utilizes the first data field of the message to indicate the function of the message. Two functions are provided:

a) Transmit PGN List providing a list of all parameter groups transmitted by a device, and
b) Received PGN List providing a list of all parameter groups received by a device.

7.3.1 Transmitted PGN List

The Transmitted PGN List PGN includes:

- Group Function code set to 0x0 indicating this message is a Transmitted PGN List message.
- Multiple field list of all PGNs that this device is capable of transmitting.

1. All devices shall support the Transmitted PGN List message containing all transmitted messages supported by the device, including Data Link and Network Management messages.
2. The Transmitted PGN List message shall be implemented as described in Appendix A.

7.3.2 Received PGN List

The Received PGN List parameter group includes:

- Group Function code set to 0x1 indicating this message is a Received PGN List message.
- Multiple field list of all PGNs that this device is capable of receiving.

1. All devices shall support the Received PGN List message containing all received messages supported by the device, including Data Link and Network Management messages.
2. The Received PGN List message shall be implemented as described in Appendix A.

7.4 ISO 11783-5 Requirements

Table 8-1 summarizes the recommendations (e.g., “recommended”, “should”, and “may” terminology) in ISO 11783-5 that are requirements of this standard. The terminology “will/will-not and must/must-not” used in ISO 11783 is considered equivalent to the terminology “shall/shall not” used in this standard.

Table 8-2 ISO 11783-5 Requirements	
4. NAME and Address Requirements	NAME shall indicate the device function
4. NAME and Address Requirements	NAME shall be used in arbitration for addresses
4.1 NAME	Each device on the network shall have at least one NAME so the device can be uniquely identified by its function
4.1.6 Reserved Field	The reserved bit shall be set to zero
4.1.11 Identity Number Field	This field shall be unique and non-varying with removal of power
5.2.1 Request Message for Address Claimed	Devices which have not yet attempted to claim an address shall not participate in network communications until the device has attempted to claim an address. These devices shall not send a Cannot Claim Address message or any other message until an address claim has been attempted. A device shall also respond to its own request for Address Claimed message.
5.2.2 Address Claimed/Cannot Claim	If a device receives an Address Claimed message claiming its own source address it shall compare the NAME that was

	received in the Claimed Address message with its own NAME and determine which device has a higher priority NAME, that is a lower numeric value. … However if it has the lower priority NAME it shall either claim a new address or send a Cannot Claim Source Address message. A network interconnection ECU shall not use it’s own address in communications on the network until it has successfully claimed an address.
5.4.1 Address Claim Requirements	The destination address for an Address Claimed message shall be global (255) to "announce" the claim message to all ECUs on the network. A device shall not begin or resume transmitting on the network until 250 milliseconds after it has successfully claimed an address.
5.4.2.1 Response to a Request for Address Claimed sent to the global address	An ECU shall always respond to a Request for Address Claimed directed to the global address with either an Address Claimed message or if the ECU has not been successful in claiming an address, a Cannot Claim Source Address message.
5.4.2.2 Response to a Request for Address Claimed sent to a specific address	An ECU shall always respond to a Request for Address Claimed where the destination address is equal to the ECU's address. The response to the request, the Address Claimed message, shall be sent to the global address (255).
5.4.2.3 Response to Address Claims of own address	An ECU shall transmit an address claim if it receives an Address Claimed message with a source address that matches its own, and if its own NAME is of a lower value than the NAME in the claim it received. If the ECU's NAME is of a higher value than the NAME in the claim it received, the ECU shall not continue to use that address. (It may send a Cannot Claim Source Address message or it may attempt to claim a different address.)
5.4.2.4 Contention for an address	An ECU that discovers it cannot use an address shall either send a Cannot Claim Source Address message … or select another address and attempt to claim that address.

5.4.3.3 Address Claim Prioritization	The NAME shall be treated as an 8-byte value with the most significant bit at the Self-Configurable Address bit for determining numerical value. If multiple ECUs have the same address and different NAME, simultaneous Address Claimed messages will result in bus errors. To protect against modules generating bus errors (until going bus off) the following special processing shall be used when transmitting claim messages. After transmitting any claim message, the transmitting ECU shall monitor error code information. If the error code indicates that a bus error has occurred, any automatic retransmission attempts by the CAN peripheral shall be canceled if possible. The retransmission of the claim message should be rescheduled after the standard idle period plus a transmit delay. The transmit delay should be calculated using the procedure detailed in clause 5.4.4. Figure 4 in Annex A illustrates the process of simultaneous claims by two ECUs of the same address.
5.4.3.4 An ECU which cannot obtain an address.	The ECU shall respond to a request for Address Claimed with a Cannot Claim Source Address message. In the case where there is a collision of the Cannot Claim Source Address messages, the process in clause 5.4.3.3 shall be used. An ECU which cannot claim an address shall not send any messages except for: - A Cannot Claim Address message in response to requests for Address Claimed - Respond to a Commanded Address message - A request for Address Claimed message
5.4.4 Self-Configurable Addressing ECU Address Claimed	Self-Configurable Addressing ECUs shall scheduled the Address Claimed message after its Power On Self Test (POST) period plus a transmit delay.

8 Minimum Message Implementation

A device shall implement the Data Link Layer and Network Management messages listed in Table 9-1 at a minimum.

Table 9-1 – Minimum Message Implementation	
PGN	**Message Name**
NMEA 126208	Request/Command/Acknowledgment Group Function
ISO 59392	Acknowledgment
ISO 59904	Request
ISO 60160	Transport Protocol, Data Transfer *
ISO 60416	Transport Protocol, Connection Management *
ISO 60928	Address Claim
NMEA 128768	Product Information
NMEA 126464	Transmit/Receive PGN List Group Function

Appendix A – Application Layer (Parameter Group Definitions)

Appendix B – ISO 11783-3 Data Link Layer

Appendix C – ISO 11783-5 Network Management

Appendix D – ISO 11898 Controller Area Network (CAN)

Appendix E – Application Notes